Inhibitory mechanisms contribute to differing rates of false memories in children.

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Abstract

Memory retrieval is thought to involve processes that activate relevant information and inhibit irrelevant information. Therefore, children who demonstrate impaired cognitive inhibitory processes may show greater susceptibility to false memories. To test this hypothesis, 149 children aged eight and ten were designated as inefficient or efficient inhibitors on the basis of Stroop interference. False memories were measured as the intrusion of critical non-presented lure words. Results indicate children designated as inefficient inhibitors produce significantly higher rates of false memories than children designated as efficient inhibitors. Children designated as inefficient inhibitors were also more certain as to the veracity of their false memories. These findings support the claim that children who have difficulty inhibiting responses in the face of competing or distractor information are more susceptible to false memories.

1 Introduction

While researchers have demonstrated that younger children are more susceptible to errors in memory recall than older children or adults (e.g., Ceci & Bruck, 1995; Ceci & Huffmann, 1997); age-related differences alone are unable to account for individual variations in the occurrence of false memories (Bruck, Melynk & Ceci, 1997). For example, some preschoolers are highly resistant to false suggestions, insisting the interviewer is incorrect or reminding them of earlier responses, whereas some older children readily assent to false suggestions (Bruck et al., 1997; Ceci & Bruck, 1995). In view of such findings, Bruck et al. suggest external and internal factors may account for individual as well as age-related differences. While external factors, such as repeated suggestive interviewing, have been widely researched (e.g., Bruck & Ceci 1999; Ceci & Bruck 1995; Ceci & Huffmann, 1997; Principe & Ceci, 2002; Quas & Schaaf, 2002); internal factors such as developmental changes in memory and cognition, and individual differences in behavioural inhibition, require further investigation (Bruck et al., 1997; Shilling, Chetwynd & Rabbitt, 2002).

To increase the validity of this research, Bruck et al. (1997) propose that the definition of false memories requires clarification. Bruck et al. suggest false-beliefs arise when a child believes suggested events occurred, whereas false-reports arise when a child incorrectly assents to false or misleading information. This distinction is necessary as different factors may result in some children being susceptible to false-beliefs and others to assenting to false information. For example, false beliefs may arise from cognitive factors such as inhibitory mechanisms, which control behavioural and cognitive processes (Barkley, 1990; Bruck et al., 1997; Shilling et al., 2002).

Interest in false memories has led to an increase in research regarding errors in memory, and whether these equate to false memories of entire events. This interest has arisen as a result of public and media concern regarding allegations of child sexual abuse (CSA; Ceci & Bruck, 1995; DePrince, Allard, Oh, & Freyd, 2004). Critiques of such research argue laboratory evidence of false memories does not indicate that false memories of entire events can be implanted, especially memories of traumatic events relating to CSA (DePrince et al., 2004; Smith et al., 2003). Despite such criticism, laboratory research is needed to identify the conditions under which false memories are likely to occur. However, as DePrince et al. (2004) point out, numerous types of memory errors are referred to as “false memories”; for example, spontaneous confabulation, false confessions, and distorted memories. Hence, the present study defines a “false memory” as a memory of a non-occurring event that is related to the general theme of occurring events.

Nature and Scope of the Investigation

The aim of the present study is to investigate the role of inhibitory control in the generation of false memories. Specifically, whether children who demonstrate inefficient inhibition produce higher rates of false memories than children who demonstrate efficient inhibition. A Stroop colour-naming task was used to assess cognitive inhibition (Dalrymple-Alford & Budayr, 1966; Stroop, 1935). This task utilises two conditions: a neutral condition in which a string of letters is presented in one of four font colours, and an incongruent condition in which a colour word is presented in a conflicting colour font. Interference occurs when the semantic meaning of the colour-word causes response times to be longer in the incongruent condition than response times in the neutral condition. Children demonstrating a greater degree of interference were assigned to an "inefficient inhibitor" group, whereas children demonstrating a lesser degree of interference were assigned to an "efficient inhibitor" group. False memories were assessed using a word list task based on that of Deese/Roediger and McDermott (DRM; Roediger & McDermott, 1995). Children were shown a series of word lists, with each word relating to an overall theme or concept. After presentation of a study list, children were presented with a test list. The task was to identify test words that appeared on the study list referred to as 'Old' words, and test words that did not referred to as 'New' words. Embedded within each test list was a critical non-presented lure word (CNL) associated with the semantically related list words. A false memory is defined as a CNL incorrectly identified as an 'Old' word.

As children are regarded as being less inhibited than adults, for example displaying impulsive behavioural tendencies (Barkely, 1990), and as children are often involved in interviews relating to allegations of CSA (Ceci & Bruck, 1995), it is useful to determine whether inhibitory control accounts for individual differences in rates of false memories in children. To assist in understanding the connection between theories of false memories and the role of inhibitory processes in false memories, the literature relating to false memories will be reviewed prior to a detailed examination of theories of memory formation, retrieval, and inhibitory control. Section 2 provides an overview of false memory research relating to children and adults. Section 3 examines theories of false memory formation and retrieval, and the theoretical basis for the role of inhibitory mechanisms in memory retrieval. Section 4 presents evidential support for the role of inhibitory mechanisms in memory. Section 5 outlines how inhibitory control and false memories were tested in the current study.

2 Overview of false memory research

The following section reviews research investigating differences in rates of false memories in children and adults, and the conditions under which false memories are likely to occur. Research suggests young children are more susceptible to false memories than older children (see Ceci & Bruck, 1995 for a detailed overview of such research). However, the results of such research reveal that not all young children are susceptible to false memories, whereas some older children are highly susceptible to false memories. False memory research relating to adults indicates that individual differences in rates of false memories are related to susceptibility to suggestions and inhibitory mechanisms (e.g. Loftus, 1997; Lövden, 2003). Examination of the occurrence of false memories in children reveals that individual variations in false memories are found between children of the same age and differing ages (Bruck & Ceci, 1999), and under differing interviewing conditions (Quas & Schaaf, 2002). For example, research has shown that false memories in children can be manipulated through suggestive questioning (Bruck & Ceci, 1999), whether children do or do not experience an event (Principe & Ceci, 2002), and from source monitoring errors resulting from drawing and imagining (Strange, Garry & Sutherland 2003).

Children: Memory Recall and Suggestibility

In many ways the ability of children to accurately recall events is similar to adults (Brainerd & Reyna, 1996; 2002). However, the degree to which a child's memory can be altered by suggestive and repeated interviews is influenced by a number of factors such as age, and delay between an event and recall (Bruck & Ceci, 1999; Quas & Schaaf, 2002). According to memory retrieval theories, young children's memories are based on surface details referred to as gist based memory (Brainerd & Reyna, 1996; 2002). Gist memories decay more rapidly than memories based on verbatim details of an event, and young children's memories have been found to decay more rapidly than the memories of older children and adults (Holliday, 2003). It is on this basis that the hypothesis that young children are more susceptible to false memories than older children or adults developed.

However, early studies of the suggestibility of children rarely included preschool aged children despite the disproportionate number of preschool children involved in CSA cases (Bruck & Ceci, 1999). In view of such concerns, researchers have increasingly examined the response of young children to misleading questions relating to bodily touching that could be interpreted as sexual abuse (Bruck & Ceci, 1999; Quas & Schaaf, 2002). For example, Rudy and Goodman (cited in Bruck & Ceci, 1999) assigned pairs of four year old and pairs of seven year old children to participate in or witness play with a stranger (Bruck & Ceci, 1999). During the play session, a confederate dressed the participating child in a clown's costume, lifted, and photographed the child in the presence of the non-participating child.

Ten days after the play session, both participating and non-participating children were interviewed with open-ended questions, direct or misleading questions. Not surprisingly, children who participated in the play session were more accurate than those who had not participated. However, participating and non-participating children of both age groups were more likely to make errors in response to misleading questions. Therefore it would appear that age-related differences in the suggestibility of children disappear when children are asked misleading questions about salient events (Bruck & Ceci, 1999; Ceci & Bruck, 1995; Quas & Schaaf, 2002).

Children's Reports of Experienced and Non-experienced Events

A question that often arises from false memory research is whether children can be induced to form a false memory of an event they did not experience. Evidence that false memories can occur when children are exposed to information about non-experienced events, is found in the analyses of transcripts of interviews with children (Ceci & Bruck, 1995). In this instance, it is suggested that information obtained through everyday conversations becomes incorporated into the child's own memories, leading to a false memory of an event (Principe & Ceci, 2002). An extension of the study mentioned in the preceding section, is whether children who do not experience an event but who have access to children who have experienced an event, will be more likely to report false memories than a control group of children (Principe & Ceci, 2002).

To examine the effects of peer exposure on the recall of non-witnessed events, Principe and Ceci (2002) conducted an investigation using a staged archaeological dig. Three experimental groups were used: 1) eyewitness group - children who witnessed target activities; 2) classmate group - children who were classmates of the witnesses but did not actually witness the 'dig' themselves; and 3) control group - children who had no contact with children in groups 1 and 2. During the first session, the eyewitness group took part in a contrived dig with a fictitious archaeologist named Dr. Diggs. Children in the eyewitness group saw Dr Diggs ruin two artefacts, referred to as the target activities.

One week following the dig, all three groups were questioned a number of times in either a neutral or suggestive manner over a three week period. Both the neutral and suggestive interviews followed a structured format and began with an open-ended question about Dr Diggs' visit. For children in the neutral interview condition, open-ended probes were asked to elicit information about the target activities. Children in the suggestive interview condition were asked suggestive questions indicating how the two artefacts were damaged. Children in the suggestive interview condition were also asked to elaborate after each suggestive question.

The final interview followed a structured format with five levels of questions: open-ended, specific probe questions, source questions, counter suggestions and peer conformity suggestions. For each target activity reported at either the open-ended or specific probe level of questioning, children were given an additional probe question to verify the source of their memory. This established whether children had simply heard about the target activity or actually saw it. Those that reported actually seeing Dr Diggs ruin the two artefacts were asked a counter-suggestion insinuating the child had not witnessed the target activity (Principe & Ceci, 2002). This was to gauge the strength of the child's belief that they had actually witnessed the target activity.

Analysis of the results revealed that a combination of suggestive interviews and peer exposure led to claims by the classmate group that they had witnessed the target activities (Principe & Ceci, 2002). Thus indicating that exposure to peers who experience a salient event can lead to non-participating children producing false memories of these events. When exposed to a suggestive interview, the total recall scores of the classmate group were elevated to that of the eyewitness group. This study demonstrates that children can form false memories of an event which are indistinguishable both in magnitude and detail from those of children who experienced the event. This makes it is almost impossible to differentiate between children who actually experienced an event, and those that form a false memory of the event.

Interestingly, at the final interview children in the control group reported nearly the same number of target activities as children in the classmate group; 23 percent compared to 25 percent respectively (Principe & Ceci, 2002). The only source of information regarding target activities for those in the control group was the interviewer's questions. Repeatedly asking some of these children whether they saw the artefacts being damaged, provided sufficient information for some of them to accurately report target activities during the final interview (Principe & Ceci, 2002). However, this study does not identify which factors distinguish children who form a false memory from those that do not.

Drawing and Imagining Events

It is therefore important to understand how techniques used to obtain information from children increase the risk of false memories. For example, drawing and imagining are often used in investigative interviews (Strange et al., 2003). Justification for using these techniques has been based on studies indicating that children talk more freely about their experiences and report more information when they draw and imagine events (Strange et al., 2003). Moreover, this has been suggested to be true regardless of age or the emotional content of the target event. In view of these arguments, Strange et al. (2003) investigated whether children form false memories of impossible events, based on a failure to distinguish imagining that an event occurred from internally generated memories.

Children were randomly assigned to one of two experimental groups, draw and no-draw. Both groups were first asked whether a list of events had occurred, including a number of target activities such as flying to the moon on a rocket. Target activities were chosen because it was impossible for them to have occurred, however they were easily imagined and are the subject of children's stories, television programmes, and fantasy games. Two weeks later, children in the draw group were randomly assigned three target activities (Strange et al., 2003). Children were asked to draw a picture of what it would be like if the target activity happened, and to tell the interviewer everything about their drawing. If information was not given spontaneously, then questions which encouraged elaboration were asked. The last phase of the experiment was conducted one hour after drawing, when both groups were again asked to respond "yes" or "no" to the list of events.

A general trend was evident; children assigned to the draw group were more likely to change their responses from "no" prior to drawing the event to "yes" responses (Strange et al., 2003). This implies that the act of drawing combined with imagining and describing feelings relating to an event, increases the likelihood that children will claim these events occurred. Illustrating that information obtained from external sources can become incorporated into the child's memory, resulting in the child attributing the source of the information to an internally generated memory. However, consistent with research already outlined, not all children who were asked to draw and imagine an event developed a false memory of the event. Thus, while research indicates younger children are more susceptible to false memories than older children; such research fails to address the question of why differences in rates of false memories exist between children of the same age and between children of different ages. Nor does this research identify the memory processes related to individual differences in the formation of false memories.

Adults: Individual Differences in False Memories

To assist in understanding factors related to individual differences in rates of false memories, it is necessary to look at false memory research pertaining to adults. For example, whether techniques used to assist adults recall early childhood memories increase rates of false memories, and whether factors such as susceptibility to suggestions mediates an increased rate of false memories. Those involved in counselling individuals who claim to have recovered memories of traumatic child abuse, suggest memories of traumatic events are preserved in a manner that protects such memories from decay or distortion (Gleaves & Smith, 2004; Loftus, 1997; Lynn, Loftus, Lilinfeld, & Lock, 2003;). This has led many to assert that the use of techniques, such as hypnosis and guided imagery, facilitates the accurate retrieval of 'preserved' memories (Lynn, et al., 2003). However, despite an absence of empirical evidence to support the use of mnemonic techniques, these methods remain common psychotherapy and forensic interviewing tools (Bruck & Ceci, 1999; Ceci & Bruck, 1995; Loftus, 1997; Lynn et al., 2003).

Research also indicates some adults are more susceptible to false memories than others. To answer the question of whether individual differences in susceptibility to false memories occurs in adults, researchers typically compare differences between specific groups or differences between older and younger adults. For example, Clancy et al. (2002) report differences in rates of false memories between adults claiming to have recovered repressed memories of child abuse and matched controls. Furthermore, those reporting memories of alien abduction also report higher rates of false memories of words not presented on studied word lists than matched controls.

A recent study conducted by Lövden (2003) indicates inhibitory mechanisms are related to individual differences in rates of false memories. Adults aged 20 to 80 were assessed using a variety of inhibitory control measures, and false memories were assessed by the number of CNLs recognised as studied words. Those that were assessed as having impaired inhibitory control were also found to produce higher false memory rates. Lövden suggests impaired inhibitory processes fail to reduce activation of associatively based information. This in turn results in a higher false recognition of words associatively related to study words, but not presented during the study phase (Lövden, 2003). While Lövden suggests caution when interpreting such findings, it appears inhibitory processes contribute to discriminating between target memories and memories that are similar but incorrect. Such evidence indicates a need for further research to determine whether inhibitory mechanisms contribute to higher rates of false memories. To assist in such research, it is necessary to consider the theoretical foundation for the role of inhibition in memory processes, and in particular the role of inhibitory control in false memories.

3 Theoretical basis of inhibition and false memories

Two theoretical approaches will be considered to account for the relationship between inhibitory control and false memories, Fuzzy Trace Theory (FTT; Brainerd & Reyna, 1996; 2002) and activation-suppression (Tipper, 1985). The role of inhibitory control in memory will also be examined, to establish a basis for the claim that children who demonstrate less efficient inhibitory control may be susceptible to higher rates of false memories. As the present study measured false memories on the basis of intrusions of words related to the overall semantic concept but incorrect in relation to the exact details of the event, an explanation of the role of inhibition of competitor information will also be given.

Fuzzy Trace Theory

Evidence suggests adults and children encode events in either verbatim memory traces retaining exact details of an event or information, or gist memory traces retaining concepts and relations representing an event (Brainerd & Reyna, 1996). Fuzzy Trace Theory (FTT; Brainerd & Reyna, 1996; 2002) provides a detailed process model accounting for memory editing operations, referred to as Recollection Rejection processes (RR). Through the process of RR familiar gist-consistent events or statements are neutralised by accessing verbatim memory traces, generating either a match and therefore acceptance or a mismatch and therefore rejection. Events that are gist-inconsistent are likely to be rejected whereas events that are incorrect yet gist-consistent are more likely to be accepted (Brainerd & Reyna, 2002).

In recognition tests, false gist-consistent events are more likely to be incorrectly identified than false gist-inconsistent events (Brainerd & Reyna, 2002). Brained and Reyna suggest that activation of verbatim memory traces by false gist-consistent events increases the likelihood that false information will be incorrectly accepted. According to FTT, verbatim and gist based memories are formed simultaneously resulting in two distinctive representations of an experience. This is crucial in explaining how true and false memories of the same event can arise and co-exist, distinguishing false memories from errors in memory. Put another way, children who incorrectly recognise non-presented semantically related words as previously presented on the basis of gist-consistency, may also correctly recognise previously presented words on the basis of verbatim memory traces.

Activation-Suppression Models

According to activation-suppression models of attention (Neumann, DeSchepper, 1991; Tipper, 1985) when selectively attending to a target, excitatory mechanisms enhance or maintain an internal representation of the target while inhibitory mechanisms actively inhibit or suppress irrelevant distractors. Therefore, tasks that include irrelevant distractor information require a greater degree of inhibitory efficiency than tasks that do not include irrelevant distractor information. An example of a task requiring inhibitory control is the Stroop colour-naming task (Neill & Westbury, 1987; Schooler, Neumann, Caplan & Roberts, 1997). This task requires participants to ignore the semantic meaning of a colour-word in order to respond to the colour the word is presented in. Reduced response times occur in conditions where the meaning of the word is congruent to the presentation colour, whereas increased response times occur in conditions where the meaning of the word is incongruent to the presentation colour, referred to as Stroop interference. Stroop interference has been proposed to result from the inability to suppress irrelevant information, such as the automatic extraction of the meaning of word when the task is to identify the ink colour a word is presented in (Dalrymple-Alford & Budayr, 1966). Efficient behavioural inhibition is thought to be partially reliant on attentional resources, for example, high processing load has been found to increase the degree of Stroop interference due to decreased attentional resources (Chen, 2003). If inhibitory control plays a core role in executive functioning (Barkley, 1990) then children who demonstrate less efficient inhibition should also exhibit a greater degree of Stroop interference, evident in slower reaction times, higher error rates, or both (Barkley, 1990, Lövdén, 2003; Shilling, et al., 2002). By extension, less efficient inhibitory control should also result in higher rates of false recognition on tasks requiring inhibition or suppression of competing information, such as incorrectly identifying new words as previously presented in a word list.

Inhibitory Control

An important process in the formation of memories is the ability to attend to relevant information, while at the same time inhibiting irrelevant information and behavioural responses (Anderson & Spellman, 1995). According to Barkley (1990) inhibition may involve three distinct components: (1) inhibition of a response associated with positive or negative reinforcement; (2) inhibition of an ongoing response that is inappropriate or inaccurate as a result of changes in task demands; and (3) inhibition of interference from competing events or distractors (Barkley, 1990; Barkley et al., 2001; see also Lawrence et al., 2002). These three aspects of inhibition are evident in the behavioural problems associated with children diagnosed with attention deficit hyperactivity disorder (ADHD), who demonstrate developmentally inappropriate impulsive behaviour (Barkley, 1990; Barkley et al., 2001; Lawrence et al., 2002). Impaired inhibitory control not only impacts on behavioural responses but also impacts on the ability to attend to and ignore information. For example, Lawrence et al. found children with ADHD showed significant impaired inhibitory control on a task requiring selective attention and behavioural inhibition of responses in relation to distractor information. While impaired inhibitory control is evident in children with ADHD, inhibitory control may also impact on the ability to attend to and ignore information in children without ADHD.

Inhibitory control is also important in the ability to distinguish relevant information from competing information. For example, Anderson, Green, and McCulloch (2000) investigated whether inhibitory processes function to discriminate target information from competing information. In this case, the authors found that the degree to which information competed with target information increased the need for inhibition (Anderson et al., 2000). When information was shared between two competing units, a greater degree of inhibition was required. Likewise, when target information was distinct from competing information the amount of required inhibition was reduced. Therefore, increasing the degree that information competes with target information also increases the amount of inhibitory processes needed to produce a correct response. In view of this, impaired inhibitory control may be evident in a task requiring inhibition of distractor information, such as the Stroop colour-naming task and the DRM word list task.

4 Evidential support for the role of inhibition in false memories

The following section examines evidential support for the proposal that inhibitory processes may contribute to the occurrence of false memories. While some researchers conclude errors in memory recall results from limited attentional resources (see Anderson & Bell, 2001), Anderson and colleagues (2001; 2000) suggest such errors occur as a result of the retrieval process itself. More specifically, during the process of recall the ability to overcome interference from conflicting or distractor information relies on the ability to inhibit related yet irrelevant facts (Anderson & Bell, 2001). This process of inhibitory control in memory is also consistent with other cognitive domains, such as language comprehension (Gernsbacher & Faust, 1991; Gernsbacher, Varner, & Faust, 1990), and executive control functions related to inhibition of responses (Anderson & Bell, 2001; Barkley, 1990; Lövdén 2003). In relation to the retrieval of semantically associated information, impaired recall results from an inability to effectively inhibit competing information, evident in experiments utilising retrieval-induced forgetting, or slowed reaction times in recognition tasks, or increased false recognition of words or statements not previously presented (Anderson & Bell, 2001).

Inhibition and Retrieval

To demonstrate the effect of competing information in the retrieval process, Anderson and Bell (2001) provide evidence from experiments utilising retrieval practice. When participants practice retrieving some of the facts about a presented topic, inhibition of facts not practiced is seen in the impaired recall of non-practiced facts. Additionally inhibition of related concepts is also found, such as impaired recall of topics containing similar concepts to the practiced items. While explanations based on limited attentional resources account for impaired recall of facts related to the topic but not practiced, such explanations cannot account for impaired recall of facts related to other topics containing similar concepts (Anderson & Bell, 2001). In much the same way as visual selective attention allows objects to be attended to, Anderson and Bell suggest inhibitory mechanisms facilitate retrieval of active concepts by inhibiting or suppressing competing concepts. Therefore, highly active competitor concepts that are inefficiently inhibited intrude in recall (Anderson & Bell, 2001). On this basis, ineffectively inhibited irrelevant information may produce higher rates of false recall of a word related to the thematic concept of a word list, yet not presented during the study phase.

Inhibition and Language Comprehension

Further evidential support for the role of inhibitory control in memory comes from the work of Gernsbacher and colleagues (1999). This research demonstrates inhibitory mechanisms play a role in retrieving the meaning of words. For example, when presented with words information that is associated with the meaning or possible meaning of a word is activated. This process of inhibition is evident in impaired performance. Specifically, when presented with the sentence *He lit the match* the inappropriate meaning of the word ‘match’ becomes suppressed. The cost of this suppression is evident when participants are later required to determine whether the sentence *He won the match* makes sense. In this instance, participants are considerably slower to respond. Explanations based on activation and decayed activation cannot account for such an inhibitory cost, as the alternative meaning of match should have decayed overtime and not impede the subsequent comprehension decision (Gernsbacher & Robertson, 1999).

Inhibition and Attention Deficit Hyperactivity Disorder

As ADHD is described as behavioural and cognitive impairment across dimensions of attention and inhibition, it is useful to review research that examines the role of inhibitory control in ADHD (Barkley, 1990; Barkley et al., 2001). To answer the question of whether children with ADHD have impaired abilities to comprehend information when the task requires inhibition of interfering or competing information, McInnes et al. (2003) examined whether children with ADHD are able to inhibit interference from competing information as well as children without ADHD. Results indicate children with ADHD show significant impaired ability to make inferences based on subtle aspects of a passage of text, and when monitoring their comprehension of instructions. Consistent with the work of Gernsbacher and colleagues, McInnes et al. conclude that the process of comprehending complex information requires efficient inhibitory control mechanisms which facilitate accurate responses. For example, the process of holding on-line information at the same time as forming mental representations of that information, and the ability to retrieve the relevant information while inhibiting irrelevant information (McInnes et al., 2003).

The ability to hold and manipulate mental representations is thought to be an executive function domain (Barkley, 1990). Barkley et al. (2001) examined whether adolescents with ADHD show deficits on tasks requiring response inhibition and efficient working memory processes. Adolescents with and without ADHD were assessed on measures of executive functioning. The results indicate adolescents with ADHD show no deficits on general measures of working memory. Therefore, Barkley et al. suggest rather than a global deficit in executive functioning, those with ADHD show inhibition of responses and impaired self-control reliant on cognitive process of inhibition control.

Inhibition and Brain Imagery

Through the use of event-related functional magnetic resonance imaging (fMRI), Mecklinger, Weber, Gunter, and Engle (2003) have provided further evidential support for the role of inhibitory control in memory. Previous research using fMRI technology has demonstrated that the prefrontal cortex (PFC) plays a critical role in the active maintenance of information (Mecklinger et al., 2003). The authors examined whether there are differences in activation between individuals assessed as having a high working-memory capacity (HS) and those assessed as having a low working-memory capacity (LS); also whether HS individuals and LS individuals show differences in the ability to resolve interference from competing information. As maintaining information in mind for short periods of time and ignoring information irrelevant to the current task is reliant on working memory capacity (Barkley et al., 2001), it is logical to assume that individuals who have a lower working memory capacity will show impaired ability in such tasks.

The results of this study show LS participants took longer to respond and were less accurate than HS participants (Mecklinger et al., 2003). Of specific interest, response times of LS participants were longer on trials where inhibition of irrelevant information was required compared to response times on trials where no inhibition was required. Furthermore, fMRI analysis indicates LS participants show larger activation in relation to interference effects compared to control trials. In contrast, HS participants showed enhanced control trial activation in comparison to LS participants. In explaining these findings, the authors note enhanced activation in HS participants may indicate more efficient cognitive processing mechanisms. This would also suggest that longer response times and higher error rates in LS participants result from inefficient inhibitory control mechanisms.

The research outlined in this section indicates that inhibitory mechanisms play a crucial role in the facilitation of accurate retrieval of concepts (Anderson & Bell, 2001), inhibitory mechanisms also facilitate language comprehension by inhibiting inappropriate meanings (Gernsbacher & Robertson, 1999), inhibitory control facilitates accurate retrieval of relevant information (McInnes et al., 2003), and individuals with low working memory capacity show greater response time latency when inhibition of irrelevant information is required (Mecklinger et al., 2003). As accurate recall of information is reliant on the ability to inhibit irrelevant information, efficient inhibitory control should be evident in a lower rate of false memories; conversely inefficient inhibitory control should be evident in a higher rate of false memories. Therefore, children who demonstrate inefficient inhibition may produce higher rates of false memories than children who demonstrate efficient inhibition.

5 Measuring inhibitory control and false memories

The present study measured inhibitory control using a Stroop colour-naming task. Kane and Engle (2003) suggest Stroop interference is determined by active goal maintenance and inhibition of distractor information, both of which are sensitive to individual differences. False memories were measured as the number of non-presented semantically related words incorrectly recognised as previously presented. Since Brainerd and Reyna (2002) propose that young children have the cognitive abilities to use RR processes, individual differences in false alarm rates on a word recognition test may result from deficient inhibitory-based processes. From an inhibition-based perspective, it could be argued rejecting false gist-consistent events relies on the ability to inhibit the activation of verbatim memory traces, or inhibiting responses to gist memory traces, or a combination of both.

To assess the occurrence of a false memory, the present study used a word recognition task based on modified DRM word lists (Roediger & McDermott, 1995). A number of word lists were presented to children followed by test lists. The recognition task involved distinguishing studied words from non-studied words. The critical manipulation involved the presentation of a test word that was semantically associated to the related concept of the study list that did not appear on the list itself. This word is referred to as a critical non-presented lure word (CNL). This task also included a measure of confidence in whether participants ‘Remember’ the CNL as presented in the word list or whether they ‘Know’ the CNL was previously presented. A ‘Remember’ judgement was made when the participant could visualise seeing the word on the original word list. This type of judgement is usually associated with a strong belief the test word appeared in the original word list (Roediger & McDermott, 1995). A ‘Know’ judgement was made when participants were confident the test word was on the original word list but were not able to recall exact details. This experimental design typically produces rates of false recall of CNLs that approach hit rates of studied words; also false recognition of CNLs is frequently associated with a higher number of ‘Remember’ judgments (Roediger & McDermott, 1995).

Roediger and McDermott (1995; 2002) propose that the recognition of initial test words instigates the retrieval of memory traces, which in turn enhances the activation of the remaining semantically related words and the thematically related concept produced by the semantic associations. For example, presenting the test words ‘bed’, ‘rest’, ‘dream’ and ‘doze’; enhances the activation of studied list words ‘bed’, ‘rest’, ‘dream’, and ‘doze’ as well as list words ‘awake’, ‘tired’, and ‘slumber’, and the associated theme of ‘sleep’. When the CNL ‘Sleep’ is presented, false recognition is primed by the previous activation of semantically related test words and the thematic concept of ‘sleep’. This explanation is supported by the finding that false alarm rates increase when the CNL is presented towards the end of a set of related items (Roediger & McDermott, 1995). Remember judgments also increase due to repeated activation of the theme, which induces the participant to construct a mental image of the CNL within the presentation context. In accordance with this perspective, if word-lists are presented audibly participants report remembering how the critical word sounded; conversely, when word lists are presented visually participants report remembering how the CNL looked (Roediger & McDermott, 1995).

Recent research by Watson, Balota and Roediger (2003) utilising hybrid lists including both semantically associated and phonologically associated word lists, produced higher rates of false recognition than standard DRM word lists. In constructing hybrid word lists, some of the original CNLs were substituted to allow the addition of phonological associates. For example, the CNL ‘Doctor’, used in the original DRM word list, was exchanged for the word ‘Sick’, allowing the addition of phonological associates ‘kick’, ‘pick’ and ‘tick’. In all cases, the phonological associates are related both orthographically and phonologically to the corresponding CNL. For example, replacing the letter ‘s’ in ‘sick’ with either a ‘k’, ‘p’ or ‘t’ retains the number of letters, their order within the word, as well as their rhyming association to the CNL.

In a hybrid list, the only word associated to the overall theme of the list words and the additional phonological associates, is the CNL (Watson et al., 2003). By including phonological associates, participants may have more difficulty in determining whether the CNL was presented in the original list through activation of verbatim memory traces, or whether it looks and sounds similar to words on the presented list based on activation of gist memory traces. These findings are consistent with FTT, as the semantic and phonological associates’ relationship to the CNL appears to increase both the activation and retrieval of verbatim memory traces, together with gist memory traces (Brainerd & Reyna, 2002).

Consistent with FTT (Brainerd & Reyna, 2002), presenting information that is “true” increases the familiarity of verbatim memory traces, at the same time as increasing the familiarity of the gist memory trace (Lövden, 2003). As list words are presented during testing, this should increase the familiarity of the gist memory trace. Therefore, when children who are inefficient inhibitors incorrectly identify the CNL as an “Old” word, they should also experience a heightened sense of familiarity associated with the CNL and the gist memory trace. This should be evident in a higher rate of “Remember” judgments associated with the CNLs. In contrast children designated as efficient inhibitors should experience a lesser degree of familiarity associated with the CNL and gist memory traces, evident in a lower rate of “Remember” judgments associated with CNLs.

Four hypotheses were tested in the present study. First, children aged 8 years were expected to produce a higher rate of false recognition of CNLs than children aged 10 years. Second, children who demonstrate inefficient inhibition irrespective of age were expected to produce higher false alarms rates of CNLs, when presented with both semantic word lists (SW list) and semantic and phonological word lists (SPW list). Third, children who demonstrate inefficient inhibition were expected to produce higher false alarms rates on word lists containing semantic associates and three phonological associates than word lists containing semantic associates and three non-associated words. Finally, children who demonstrate inefficient inhibition were also expected to record more ‘Remember’ judgments in relation to the false recognition of CNLs from the semantic plus phonological word lists, than children who demonstrate efficient inhibition.

6 Method

Participants

One hundred and ninety-three children aged eight and ten years, were recruited from primary schools, including 34 children who participated in a pilot study and 10 children who were excluded because they did not understand the instructions. Eligibility criterion was age, reading ability, comprehensive grasp of English, and normal or corrected to normal vision. Information regarding reading ability and comprehension of English was obtained from teachers. Refreshments were offered as incentive to participate.

Materials and Design

Stroop trials consisted of incongruent and neutral conditions. The incongruent condition comprised colour-words, ‘blue’, ‘red’, ‘yellow’, and ‘green’ presented in one of four colours - blue, red, yellow, and green. The neutral condition comprised letter strings presented in blue, red, green, or yellow. For example ‘juchw’ to correspond to the number of letters in the word ‘green’, or ‘zopt ’ to correspond to the number of letters in the word ‘blue’, etc. Reaction times (RT) and error rates were measured.

Stroop trials consisted of ten practice trials, and 300 test trials of which 50% were incongruent trials and 50% were neutral trials, presented in random order. Participants were ranked according to percentage of Stroop RT interference and Stroop error rate, allowing the formation of an inefficient inhibitor group and efficient inhibitor group.

The word list task comprised study words arranged into twenty 13-word lists (Appendix 1). Two list types were used, Semantic Word Lists (SW list) containing 10 semantically associated words and three non-associated words, and Semantic plus Phonological Word Lists (SPW list) containing 10 semantically associated words with three phonologically associated words. Twenty SPW test lists and 20 SW test lists were compiled, each with five studied words, four non-studied words selected from non-presented word lists and the CNL from the presented list.

A mixed design was used for the Word list task: between-subjects variables being age (8 versus 10 year olds), and group (inefficient inhibitors versus efficient inhibitors); within-subjects variable being list type (SPW lists versus SW lists). Word list trials were counterbalanced to ensure an even presentation of both list types. A Compaq Armada E500 laptop, a Toshiba Satellite Pro 480CDT laptop, and Compaq S720 computers were used to present Stroop stimuli and word lists.

Procedure

Approval to conduct this research was obtained from the Human Ethics Committee, Canterbury University. Letters of explanation and consent forms were distributed to parents via local primary schools. Assent to participate was obtained verbally and by signed consent from each child (Appendix 3). Children were taken in small groups to a room set aside for the experiment, with each participant completing the experiment individually. One hour was allocated to complete both tasks.

A Microsoft Power Point presentation was used to explain the Stroop task. All words and letters were presented in Arial Unicode ms regular 48 white font in the centre of the screen against a black background. Instructions were also read aloud to each child (Appendix 4). Responses were made by pressing the coloured star that matched the font colour; blue, green, red, and yellow stars were placed on the ‘z’, ‘c’, ‘b’, and ‘m’ keys.

A Microsoft Power Point presentation was used to familiarise children with the Word list task. Children were made familiar with the concept of ‘Old’ and ‘New’, and ‘Remember’, and ‘Know’ events (Appendices 5 and 6). A ‘Remember’ event was explained as an event in which the child is able to recall the context in which the event occurred. A ‘Know’ event was described as an event in which the child recalls knowing a piece of information but not the context.

Word lists were presented using Microsoft Power Point, at a rate of one word per slide per second. A 30 second delay period between study list and test was used for 8 year olds and a 60 second delay for 10 year olds. During the delay period, participants wrote multiplication tables on the paper provided. Test words were shown individually for 10 seconds each. Children indicated whether the test word was a “New” or “Old” word, by ticking the appropriate box (Appendix 7). Remember and Know responses were made in the same manner. Study and test words were presented in Arial Unicode ms regular 56 white font in the centre of the screen against a black background. On completion of the word list task, participants were asked to indicate how well they understood the meaning of the words (see Appendix 3). This identified children who may not have had an adequate reading and comprehension level. At the completion of the experiment, children who participated received a thank you certificate, and their parents received a debriefing letter that explained the nature of the false memory experiment.

Responses were scored according to whether they related to False Alarms, i.e. false recognition of CNLs; Correct Rejections, i.e. correctly recognising CNLs as new words, or correctly recognising new words as new; Hits, i.e. correctly recognising old words; Errors, i.e. incorrectly recognising new words as old; and Misses, i.e. incorrectly recognising old words as new; as outlined in Table 1.

Table 1 Scoring of Word Lists

Type of response	Code	Response
False Alarm	1	Critical lure remember
False Alarm	2	Critical lure know
Correct Rejection	3	Critical lure new
Correct Rejection	4	New
Hit	5	Old remember
Hit	6	Old know
Errors	7	Old
Misses	8	New

7 Results

Formation of Groups

Data was collected from 149 children. Excessively long or short Stroop reaction times (RT) were removed, e.g. more than 5 seconds and less than 1 second. Percentage of Stroop RT interference and error rates were calculated. Participants were ranked according to Stroop RT interference and then according to percentage of errors, allowing participants to be assigned to one of three groups. Those with Stroop RT interference □8 % were assigned to the inefficient inhibitor group (n = 51), containing 25 eight year olds (15 males and 10 females), and 26 ten year olds (8 males and 18 females). Those with Stroop RT interference □ 3 % were assigned to the efficient inhibitor group (n = 47), containing 24 eight year olds (11 males and 13 females), and 23 ten year olds (7 males and 16 females). The third group containing 51 participants could not be classified as inefficient or efficient inhibitors and were excluded from further analyses (see Appendix 2 for Stroop RT and error data).

A factorial analysis of variance (ANOVA) was used to determine whether mean Stroop RT inference differed significantly between the inefficient inhibitor group and the efficient inhibitor group (M = 11.75 vs M = 1.33). Percentage of Stroop RT interference was selected as the dependent variable; age and group were selected as categorical factors. This produced a significant main effect of group, $F(1,90) = 276.65$, $p < 0.01$, no other main effects or interactions were significant. This confirms that there is no overlap in terms of Stroop RT interference between the two groups. Percentage of errors were also analysed to determine whether there was a significant difference between the inefficient inhibitor group and the efficient inhibitor group (M = 4.44 vs 2.63), with errors selected as the dependent variable, age and group were selected as categorical factors. This produced a significant main effect of group $F(1,90) = 6.57$ $p < 0.05$; those in the inefficient inhibitor group made more errors on the Stroop task than those in the efficient inhibitor group. No other main effects or interactions were significant.

False Memories

A 2 (age: eight, ten) X 2 (group: inefficient inhibitors, efficient inhibitors) X 2 (list: SPW, SW) repeated measures ANOVA was used to analyse differences in false memory rates between the inefficient inhibitor group and the efficient inhibitor group. The dependent variables selected were percentage of CNLs recognised in relation to SPW and SW lists, with age and group selected as categorical factors, and list type selected as the within group effect. The results support the hypothesis that children in the inefficient inhibitor group are more susceptible to false memories than those in the efficient inhibitor group. Specifically, children in the inefficient inhibitor group produced a higher rate of false memories than those in the efficient inhibitor group, $F(1,90) = 6.42$, $p = 0.01$. Also, children aged 10 produced a significantly higher overall false memory rate than those aged 8 (M = 72% vs 58%), $F(1,90) = 9.67$, $p < 0.01$. List type also produced a significant effect, with both groups producing a higher rate of false memories in relation to SPW lists than false memories in relation to SW lists (M = 69% vs 58%), $F(1,90) = 8.13$, $p < 0.01$. However, while the interaction between group and list was not significant, this was in the direction predicted. Children designated as inefficient inhibitors produced a higher percentage of false memories in relation to SPW lists than SW lists, with this rate being higher than the percentage of false memories of efficient inhibitors, shown in Table 2.

Table 2 Mean Percentage of False Memories

	Group	
	Inefficient Inhibitors	Efficient Inhibitors
Overall FM	70% (3.11) *	59% (3.24) *
FM:SPW Lists	74% (3.62) ns	64% (3.77) ns
FM: SW Lists	66% (4.14) ns	53% (4.31) ns
Remember Judgements	45% (3.48) **	35% (3.63) **
SPW Lists * **	51% (4.26) ns	37% (4.26) ns
SW Lists * **	39% (4.04) ns	30% (4.21) ns

Note
FM = False memory
SPW = Semantic plus phonological associates word list
SW = Semantic plus non-associated word lists
*** =** significant difference between groups, $p < 0.01$
** = significant difference between groups, $p < 0.05$
*** = significant difference between lists, $p = 0.01$
ns = non-significant interaction
Standard Errors are presented in parentheses

A repeated-measures ANOVA was used to analyse differences in critical lure remember judgments between groups. This produced a significant main effect of group, with a higher percentage of children in the inefficient inhibitor group indicating they were more certain they saw the CNL in the study list than children in the efficient inhibitor group, $F(1,90) = 3.93$, $p = 0.05$ (see Table 2). This supports the hypothesis that children designated as inefficient inhibitors produced higher rates of CNL remember judgments than those designated as efficient inhibitors. A significant effect of list type was also found, $F(1,90) = 10.68$, $p < 0.01$, more remember judgments were made in relation to SPW lists than SW lists.

Correct and Incorrect Responses

Percentages of correct and incorrect responses were examined to determine whether children in the inefficient inhibitor group produced higher rates of false memories as result of memory errors. A series of repeated measures ANOVA's were used, with percentage of Hits, Correct Rejections, Errors, and Misses selected as dependent variables, with age and group as categorical factors, and list type as the within group effect; mean percentages are reported in Table 3. In relation to Hits, the results revealed that children aged 10 correctly identified more list words than children aged 8 (M = 80% vs M = 66%), $F(1,90) = 17.89$, $p < 0.01$. List type also produced a significant within group effect $F(1,90) = 5.35$, $p < 0.05$, with significantly more list words in the SW list correctly recognised than in the SPW list. There was no main effect of group.

In relation to correct rejections of new words, group produced a main effect; children in the efficient inhibitors correctly rejected more test words than inefficient inhibitors (see Table 3), $F(1,90) = 5.41$, $p < 0.05$. Age also produced a main effect, children aged 10 correctly rejected more new words than children aged 8 (M = 74% vs 61%), $F(1,90) = 13.23$, $p < 0.01$. Age and group interacted, 10 year olds in the inefficient inhibitor group produced a higher rate of correct rejections (M = 85%), than 10 year olds in the efficient inhibitor group (M = 80%), and more than children aged 8 in the efficient inhibitor group (M = 74%), and children aged 8 in the inefficient inhibitor group (M = 56%), $F(1,90) = 6.06$, $p < 0.05$. There was no main effect of list.

Table 3 Mean percentage of words correctly and incorrectly recognised

	Group	
	Inefficient Inhibitors	Efficient Inhibitors
Hits (old words)	76% (2.37) ns	71% (2.47) ns
Correct rejection (new words)	64% (2.39)*	72%(2.49)*
Errors	28% (2.70) ns	21% (2.82) ns
Misses	25% (2.46) ns	29% (2.59) ns

Note
Errors = new words incorrectly recognised as old
Misses = old words incorrectly recognised as new
* = significant difference, $p < 0.05$
ns = non-significant
Standard Errors are presented in parentheses

In relation to errors, children aged 8 incorrectly identified more test words as 'Old' than children aged 10 (M = 34% vs 15%), $F(1,90) = 24.14$, $p < 0.01$. Age and group interacted, children aged 8 in the inefficient inhibitor group produced a higher rate of errors than children aged 8 in the efficient inhibitor group (M = 44 % vs 14 %), while children aged 10 in the efficient inhibitor group produced a higher rate of errors than those aged 10 in the inefficient inhibitor group (M = 25% vs 16%), $F(1,90) = 6.50$, $p < 0.05$. There was no main effect of group or list (Table 3).

Finally, differences were found between children in relation to incorrectly identifying list words as 'New'. Children aged eight produced a higher rate of misses than children aged 10 (M = 33% vs 20%), $F(1,90) = 13.83$, $p < 0.01$. Also, more misses were produced in relation to SPW lists than SW lists (M = 28% vs 26%), $F(1,90) = 5.04$, $p < 0.05$. Again, there was no main effect of group, (Table 3).

8 Discussion

The aim of the current study was to determine whether inhibitory processes account for individual differences in rates of false memories. Children who demonstrated inefficient inhibitory processes produced significantly higher rates of false memories than those who demonstrated efficient inhibitory processes. These results suggest that when children are presented with a list of semantically related words, individual words are committed to memory forming a verbatim memory trace while the combined presentation of list words forms a gist memory trace. Consistent with an activation-suppression account, individual list words contribute to activation of the overall semantic theme of the list. When presented with test words, children who demonstrated a greater degree of Stroop RT interference were less able to inhibit activation of the overall semantic concept of the list. This resulted in children in the inefficient inhibitor group producing a higher rate of false recognition of CNL words. Therefore, it would appear that false memories result from the formation of memory traces during the study phase and from the inability to inhibit activation of gist memory traces during retrieval.

Rates of false memories found in the present study are consistent with those reported by other researchers. For example, false memory rates were similar to hit rates (Roediger & McDermott, 1995), children aged 10 produced a higher rate of false memories than children aged 8 (Dewhurst & Robinson, 2004), and both groups produced higher rates of false memories when presented with SPW lists than SW lists (Watson et al., 2003). While overall rates of false memories for both groups were high, significant differences in rates of false memories between groups occurred; children in the inefficient inhibitor group produced a significantly higher rate of false memories than those in the efficient inhibitor group. As predicted, children in the inefficient inhibitor group were more susceptible to false memories when presented with SPW lists than children in the efficient inhibitor group. In addition, children designated as inefficient inhibitors produced significantly more 'Remember' judgments than children designated as efficient inhibitors, as well as producing more 'Remember' judgments in relation to SPW lists than SW lists.

While the hypothesis that children aged 8 would produce higher rates of false memories than children aged 10 was not supported, this may have been confounded by differences in delay times between children aged 8 and 10 (30 seconds vs 60 seconds). Therefore differences in false memories related to age should be interpreted with caution. However, if age was the main contributing factor, then differences between inefficient and efficient inhibitors would have been mediated by age. However, such an interaction was not found. Rather, whether children were designated as inefficient or efficient inhibitors was found to be the major contributing factor across all measures of false memories and memory judgments.

The finding that older children produced higher rates of false memories than younger children can be explained by two possible factors. The first relates to the nature of the experiment. As semantic networks are formed on the basis of associations between words, their meaning, the context in which they are experienced, and are influenced by exposure to education, then it would be logical to expect that children aged 10 would have developed a greater semantic network than children aged 8. The second factor relates to Fuzzy Trace Theory (FTT; Brainerd & Reyna, 1996; 2002). Brainerd and

Reyna propose that reliance on gist memory traces develops as children get older, therefore children aged 8 may rely on verbatim memory traces and be less susceptible to false memories using the DRM paradigm. However, replication of this study will need to be conducted to determine whether differences in false memories exist between children aged 8 and 10 years.

Inhibition and False Memories

The task used in the current study required participants to recognise words on the basis of retrieval of previously studied words. According to Fuzzy Trace Theory (FTT; Brainerd & Reyna, 1996; 2002) when studying word lists comprising semantically associated words, individual words are stored as verbatim memory traces while the semantic concept of the word list is stored as a gist memory trace. When asked to decide whether a test word was an ‘Old’ word or a ‘New’ word, list words are accepted as ‘Old’ words as they match the verbatim memory trace whereas the CNL word is incorrectly recognised as an ‘Old’ word as this matches the gist memory trace. Therefore, FTT accounts for differences in rates of false memories between inefficient inhibitors and efficient inhibitors on the basis that children designated as inefficient inhibitors were unable to neutralise highly familiar gist memory traces. This resulted in children designated as inefficient inhibitors producing both higher rates of recognition of CNL words as “Old” words and higher rates of “Remember” judgments.

Consistent with FTT (Brainerd & Reyna, 1996; 2002), children designated as inefficient inhibitors produced higher false memory rates than children designated as efficient inhibitors. While significant differences were found between groups in relation to false memories, this pattern was not replicated in rates of hits, correct rejections, errors or misses. In particular, while children designated as inefficient inhibitors produced a higher rate of false memories, children designated as inefficient inhibitors correctly recognised more list words as ‘Old’ words. Children designated as efficient inhibitors recognised more test words as ‘New’ words. Also, while children designated as inefficient inhibitors incorrectly recognising more test words as ‘Old’ words, children designated as efficient inhibitors incorrectly recognised more list words as ‘New’ words. If the difference in rates of false memories found between children designated as inefficient or efficient inhibitors were the result of errors in memory retrieval then it would be expected that children designated as inefficient inhibitors would produce more errors. As there were no significant differences in error rates or misses between children designated as inefficient or efficient inhibitors then false memories are not a result of errors in memory, rather they result from the inability to inhibit irrelevant gist memory traces.

The results of this study are also consistent with an activation-suppression account of memory (Neumann & DeSchepper, 1991, Tipper, 1985). Children who were less able to inhibit activation of the semantic theme of the list produced a higher rate of false memories than those who were able to inhibit activation of the semantic theme. Furthermore, the addition of three words phonologically related to the CNL resulted in a higher degree of false memories for SPW lists than for SW lists. As this occurred for both groups then it would appear that the phonological associates increased activation of CNLs, accounting for the increase in the rate of false memories for SPW lists. Children designated as inefficient inhibitors produced a higher rate of false memories in relation to

SPW lists than those designated as efficient inhibitors, confirming that those in the inefficient inhibitor group were less able to effectively suppress activation of the CNL.

Activation-suppression theory proposes memory retrieval is dependent on a dual process that activates correct target items and inhibits activated competitor items (Anderson & Bell, 2001; Levy & Anderson, 2002; Neumann & DeSchepper, 1991). A key feature of the present experiment is that presentation of list words resulted in an internal activation of the semantic theme and the CNL (Anderson & Spellman, 1995). In this case, the semantic theme and the CNL are identical. Therefore during the study phase presentation of list words resulted in activation of individual list items as well as the CNL; during the test phase retrieval of list words relied on the ability to correctly select activated list words while inhibiting the activated CNL. This process of selective retrieval from memory has been compared to the process of selective attention applied to external stimuli (Anderson & Spellman, 1995). The difference between selective attention and selective retrieval is that the false memory induced in the current experiment is a consciously experienced memory (Anderson & Spellman, 1995). This explains why children designated as inefficient inhibitors produced a higher number of 'Remember' judgments in relation to CNLs than those designated as efficient inhibitors.

Consistent and Inconsistent Findings

The finding that 10 year olds produced a higher overall false memory rate than children aged 8 years is consistent with a recent study conducted by Dewhurst and Robinson (2004). However, there are major differences between the current study and that of Dewhurst and Robinson. For example, Dewhurst and Robinson (2004) presented five word lists; each list was associated with a semantic theme, contained at least one rhyme, all words were monosyllabic, and were between three and six letters long. The current study presented ten word lists, containing either semantic plus non-associated words or semantic plus phonologically associated words, with both monosyllabic and polysyllabic words of no more than three syllables, containing between three and 11 letters. Words were selected on the basis they could be read and comprehended by children aged 8 and 10. Drewhurst and Robinson's (2004) word lists contained eight words, whereas the present study used word lists containing 13 words. The present study utilised a delay period between study and test lists, with testing consisting of a recognition task, whereas Dewhurst and Robinson tested children's memory for word lists immediately following the presentation of the study list using free recall. Therefore, Dewhurst and Robinson's experimental design may have produced a less accurate assessment of false memories in children.

By using more word lists containing 13 words and a recognition task, an accurate false memory effect could be assessed (Roediger & McDermot, 1995; Watson et al., 2003). In contrast, fewer word lists of shorter length and a free recall task may produce results related to memory decay. This appears to be evident in the low number of words recalled in Dewhurst and Robinson's study. The overall number of words recalled was low for all age groups, while the mean number of false memories was around one CNL. In contrast, the mean number of false memories reported in the present study for children aged eight was three CNLs for the SPW lists and two and half CNLs for the SW list. Children aged ten reported a mean of four CNLs for the SPW list and a mean of three and half CNLs for the SW lists.

Further Research

The pattern of results found in this study suggests inhibitory mechanisms play a crucial role in formation of false memories. However, further research is necessary to differentiate specific cognitive processes involved in inhibitory control, and whether these processes discriminate rates of false memories in children designated as inefficient or efficient inhibitors. To assist in determining these factors a series of experiments would need to be conducted in order to examine whether individual differences in inhibitory control and rates of false memories could be found. In the following section, research that indicates individual differences in inhibitory control may be able to be determined by means of negative priming, retrieval practice, working memory capacity, and differences in response times, will be briefly outlined.

The role of inhibition in tasks such as the Stroop colour-naming task has been the focus of much debate (Anderson & Spellman, 1995). Therefore, it would be useful to examine whether experimental designs that purport to assess inhibitory mechanisms, also differentiate between children that produce higher rates of false memories and those that produce lower rates of false memories. For example, the negative priming effect may reflect a suppression mechanism operating during the selection of a target item that reduces concurrent interference from distractor items (Neumann & DeSchepper, 1991). Inhibition of a distractor item incurs a response cost, evident in an increase in reaction times. When combined with Stroop-like stimuli, the ignored meaning of the colour-word becomes the target response on probe trials. Children who are able to ignore or inhibit activation of the distractor item should show a greater increase in response times as a result of inhibition of the meaning of the colour-word on the prime trial. Whereas, children who are less able to inhibit activation of the distractor item should show no such increase as they are less efficient at inhibiting the meaning of the colour-word.

As activation-suppression models and FTT imply false memories arise from processes that occur during encoding and retrieval of information, it would be useful to examine whether retrieval practice reduces rates of false memories (Anderson & Bell, 2001; Brainerd & Reyna, 1996; 2002; Neumann, & DeSchepper, 1991; Starns & Hicks, 2004; Tipper, 1985). It is theorised that correct retrieval of studied words during the test phase is reliant on dual processes; that of maintaining memory representations of the exact word as well as inhibiting competing or distractor information (Levy & Anderson, 2002). Accordingly, the activation-suppression model posits that during retrieval activation of incorrect but relevant concepts such as semantically related CNL words, must be inhibited by way of deactivation of competing representations in memory (Starns & Hicks, 2004). Therefore, items that interfere with retrieval of target words during the practice phase should be inhibited, resulting in a decrease of false recognition of CNL words during the test phase (Starns & Hicks, 2004). As a consequence, children identified as efficient inhibitors may benefit from retrieval practice evident in a reduction in rates of false memories. On the other hand, children identified as inefficient inhibitors may not benefit from retrieval practice and show no reduction in false memories.

The process of inhibiting irrelevant information is also thought to depend on working memory capacity (Mecklinger et al., 2003). Working memory maintains the availability of information for short periods of time, and may allow information that is semantically related yet irrelevant to the task or goal to be inhibited. Mecklinger et al. examined the extent to which inhibitory control mechanisms relate to working memory capacity. Their results indicate individuals with a higher working memory capacity show more inhibitory control, whereas individuals with a lower working memory capacity show less inhibitory control.

Watson and colleagues (Watson, Bunting, Poole, & Conway, 2004) also examined differences in rates of false memories and working memory capacity. Watson et al. found no differences in the occurrence of false memories between those with high or low working memory capacity. However, when participants were warned regarding the nature of the CNLs, then those with a high working memory capacity showed a reduction in false memories. The question to be examined would be whether children identified as having less inhibitory control and a lower working memory capacity, produce higher rates of false memories than children identified as having more inhibitory control and a higher working memory capacity. Also to be investigated is whether children with a higher working capacity show a reduction in false memories when warned about the CNL, and whether those with a lower working memory capacity show no such reduction.

Consistent with other studies, children designated as inefficient inhibitors in the current study were more certain as to the veracity of their false memories than children designated as efficient inhibitors. Studies of false memories typically find participants insist the false event occurred, even reporting vivid perceptual details surrounding the event (Jou et al., 2004; Loftus, 1997; Lynn et al., 2003; Payne, Neuschatz, Lampinen, & Lynn, 1997). Testing the truth of a memory by the verbal report of the subject is highly subjective. In contrast, response latency is suggested as a means of assessing cognitive processes in an objective manner. For example, Jou et al. found participants produced faster response times and were more confident when correctly recognising words when tested, and produced slower response times when less confident. In view of these findings, it is expected that children identified as inefficient inhibitors may produce faster response times and higher confidence ratings of false memories, whereas children identified as efficient inhibitors may produce slower response times and lower confidence ratings of false memories.

Implications

The outcome of this study confirms that children who had difficulty inhibiting responses also had difficulty inhibiting words related to the meaning of word lists, which did not appear on the original word list. In this way, false memories result from the inability to inhibit associated information. In the course of everyday experiences children develop networks of semantic associations. When faced with situations where they are to accurately retrieve information or events from memory, the process of retrieval activates these networks. Children who are less efficient in inhibiting activation of related but irrelevant information may incorrectly recall such information. Alternatively, when children are faced with the situation of deciding whether a specific event occurred, those that are less efficient inhibitors appear to be more likely to form a false memory of the event.

Whether the results of this study are applicable to situations in which a child is questioned regarding alleged CSA is debatable. Much of this debate centres on whether false memories of traumatic events can be induced, and whether conclusions derived from laboratory based research are valid (Gleaves & Smith, 2004; Madill & Holch, 2004; Smith et al., 2003). Researchers such as Loftus (1997) and Ceci and Bruck (1995) suggest false memories of traumatic events can be induced, and that laboratory based experiments can be generalised to situations outside of the laboratory. On the other hand, researchers such as Pezdeck and Hodge (1998) claim it is not possible to induce false memories of a traumatic event, and therefore caution should be exercised with interpreting the results of laboratory based experiments. While Pezdeck and Hodge (1998) conclude that false memories of relatively implausible events are less likely to be induced, that 46 percent of children in their study formed a false memory supports the argument for caution when questioning children regarding incidences of alleged or suspected CSA. Whether the number of children who formed a false memory is statistically significant or not, should not deter researchers from further investigating whether factors relating to the individual child (such as inefficient cognitive inhibitory mechanisms), interact with the process of memory retrieval resulting in a false memory.

While there are considerable differences in laboratory style settings and real-life settings, the results of false memory research can be generalised to other settings, such as forensic interviews. That dramatic differences in rates of false memories are found in emotionally neutral settings where a premium is placed on accurate recall, allow researchers to conclude that people may be more easily led to remember events that never occurred when the accuracy of their recall cannot be easily verified (Roediger & McDermott, 1995). On the basis of the results produced by the current study, it is suggested that the nature of questions used in forensic interviews be carefully scrutinised to eliminate questions that may inadvertently facilitate reliance on gist based memory traces rather than verbatim based memory traces.

The current study clearly shows that inhibitory mechanisms mediate individual differences in reported false memories. Consistent with previous research, the results of this study confirm some older children are more susceptible to false memories than some younger children. Thus, individual differences in inhibitory control differentiate between those that are more susceptible to false memories than those that are less susceptible to false memories. In this way, our knowledge of factors that account for differences in the occurrence of false memories has been added to. Research examining the relationship between inhibition and false memories that also identifies the cognitive mechanisms that mediate individual differences, will extend our understanding of the formation of false memories and factors related to individual differences. While the specific cognitive inhibitory mechanisms have yet to be identified, it is clear that children who are less efficient inhibitors of interference from competing information produce more false memories than children who are able to inhibit such interference.

References

Anderson, M. C., & Bell, T. (2001). Forgetting our facts: The role of inhibitory processes in the loss of propositional knowledge. *Journal of Experimental Psychology, General, 130*(3), 544 – 570.

Anderson, M. C., & Spellman, B. A. (1995). On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. *Psychological Review, 102*(1), 68 – 100.

Anderson, M. C., Green, C., & McCulloch, K. C. (2000). Similarity and inhibition in long-term memory: Evidence for a two-factor theory. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 26*(5), 1141 – 1159.

Barkley, R. A. (1990). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment*. New York: Guilford Press.

Barkley, R. A., Edwards, G., Laneri, M., Fletcher, K. & Metevia, L. (2001). Executive functioning, temporal discounting, and sense of time in adolescents with attention deficit hyperactivity disorder (ADHD) and oppositional defiant disorder (ODD). *Journal of Abnormal Child Psychology, 29*(6), 541 – 556.

Brainerd, C. J., & Reyna, V. F. (1996). Mere memory testing creates false memories in children. *Developmental Psychology*, *32*(3), 467 – 478.

Brainerd, C. J., & Reyna, V. F. (2002). Recollection rejection: How children edit their false memories. *Developmental Psychology, 38*(1), 156 – 172.

Bruck, M., & Ceci, S. J. (1999). The suggestibility of children's memory. *Annual Review of Psychology,* 419 – 431.

Bruck, M., Melynk, L. & Ceci, S. J. (1997). External and internal sources of variation in the creation of false reports in children. *Individual Differences, 9*, 289 – 316.

Ceci, S. J. & Bruck, M. (1995). *Jeopardy in the courtroom: A scientific analysis of children's testimony.* Washington, DC: American Psychological Association.

Ceci, S. J. & Huffmann (1997). How suggestible are preschool children? *Journal of American Academy of Child and Child & Adolescent Psychiatry, 36*(7), July 1997.

Chen, Z. (2003). Attentional focus, processing load, and Stroop interference. *Perception and Psychophysics, 6*, 888 – 900.

Clancy, S. A., McNally, R. J., Pitman, R. K., Schacter, D. L. & Lenzenweger, M. F. (2002) Memory distortion in people reporting abduction by aliens. *Journal of Abnormal Psychology, 111*(3), 455 – 461.

Dalrymple-Alford, E. C., & Budayr, B. (1966). Examination of some aspects of the Stroop colour-word test. *Perceptual and Motor Skills, 23*, 1211 – 1214.

DePrince, A. P., Allard, C. B., Oh, H., & Freyd, J.J. (2004). What's in a name for memory errors? Implications and ethical issues arising from the use of the term "False Memory" for errors in memory for details. *Ethics and Behaviour, 14*(3), 201 – 233.

Dewhurst, S. A., & Robinson, C. A. (2004). False memories in children: evidence for a shift from phonological to semantic associations. *Psychological Science, 15*(11), 782 – 786

Gernsbacher, M. A., & Faust, M. E. (1991). The mechanism of suppression: a component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*(2), 245 – 262.

Gernsbacher, M. A., & Robertson, R. W. (1999). The role of suppression in figurative language comprehension. *Journal of Pragmatics, 31,* 1619 – 1630.

Gernsbacher, M. A., Varner, K. A., & Faust, M. E. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(3), 430 – 445.

Ghetti, S., Qin, J. J. & Goodman, G. S. (2002). False memories in children and adults: Age, distinctiveness and subjective experience. *Developmental Psychology, 38*(5), 705 – 715.

Gleaves, D. H., & Smith, S. M. (2004). False and recovered memories in the laboratory and clinic: a review of experimental and clinical evidence. *Clinical Psychology: Science and Practice, 11*(1), 3 – 28.

Holliday, R. E. (2003). The effect of a prior cognitive interview on children's acceptance of misinformation. *Applied Cognitive Psychology, 17,* 443 – 457.

Jou, J., Matus, J. E., Aldridge, J. W., Rogers, D. M., & Zimmerman, R. L. (2004). How similar is false recognition to veridical recognition objectively and subjectively? *Memory & Cognition, 32*(5), 824 – 840.

Kane, M. J. & Engle, R. W. (2003). Working-memory capacity and the control of attention: the contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*(1), 47 – 70.

Lawrence, B., Houghton, S., Tannock, R., Douglas, G., Durkin, K. & Whiting, K. (2002). ADHD outside the laboratory: Boy's executive function performance on tasks in videogame play and on a visit to the zoo. *Journal of Abnormal Child Psychology, 30*(5), 447 – 462.

Levy, B. J., & Anderson, M. C. (2002). Inhibitory processes and the control of memory retrieval. *Trends in Cognitive Sciences, 6*(7), 299 – 305.

Loftus, E. F. (1997). Researchers are showing how suggestion and imagination can create "memories" of events that did not actually occur. *Scientific American, September,* 51 – 55.

Lövdén, M. (2003). The episodic memory and inhibition accounts of age related increases in false memories: A consistency check. *Journal of Memory and Language, 49*(2), 268 – 283.

Lynn, S. J., Loftus, E. F., Lilinfeld, S. O., & Lock, T. (2003). Memory recovery techniques in psychotherapy: Problems and pitfall. *Skeptical Inquirer, 27*(4), 40 – 46.

Madill, A., & Holch, P. (2004). A range of memory possibilities: the challenge of the false memory debate for clinicians and researchers. *Clinical Psychology and Psychotheapy, 11,* 299 – 310.

McInnes, A., Humphries, T. Hogg-Johnson, S., & Tannock, R. (2003). Listening comprehension and working memory are impaired in attention-deficit hyperactivity disorder irrespective of language impairment. *Journal of Abnormal Child Psychology, 31*(4), 427 – 444.

Mecklinger, A., Weber, K., Gunter, T. C., & Engle, R. W. (2003). Dissociable brain mechanisms for inhibitory control: effects of interference content and working memory capacity. *Cognitive Brain Research, 18*(1), 26 – 38.

Neill, W. T., & Westbury, R. L., (1987). Selective attention and the suppression of cognitive noise. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 327 – 334.

Neumann, E., & DeSchepper, B. G., (1991). Costs and benefits of target activation and distractor inhibition in selective attention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 1136 – 1145.

Paddock, J. R. & Terranova, S. (2001). Guided visualization and suggestibility: Effect of perceived authority on recall of autobiographical memories. *Journal of Genetic Psychology, 62*(3), 347 – 353.

Payne, D. G., Neuschatz, J. S., Lampinen, J. M. & Lynn, S. J. (1997). Compelling memory illusions: The qualitative characteristics of false memories. *Current Directions In Psychological Science, 6*(3), 56 – 59.

Pezdeck, K., & Hodge, D. (1998). Planting false memories in children: the role of event plausibility. *Child Development, 70*(4), 887 – 895.

Principe, G. F. & Ceci, S. J. (2002). "I saw it with my own ears": The effects of peer conversations on preschoolers' reports of nonexperienced events. *Journal of Experimental Child Psychology, 83(*1), 1 – 25.

Quas, J. A. & Schaaf, J. M. (2002). Children's memories of experienced and nonexperienced events following repeated interviews. *Journal of Experimental Child Psychology, 83*(4), 304 – 338.

Roediger, H. L. III. & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory and Cognition, 12*(4), 803 – 814.

Schooler, C., Neumann, E., Caplan, L. J., & Roberts, B. R., (1997). a time course analysis of Stroop interference and facilitation: Comparing normal individuals with individuals with schizophrenia. *Journal of Experimental Psychology: General, 126,* 19 – 36.

Shacter, D. L., Kagan, J., & Leichtman, M. D. (1995), True and false memories in children and adults: A cognitive neuroscience perspective. *Psychology, Public Policy and Law, 1*(2), 411 – 428.

Shilling, V. M., Chetwynd, A. & Rabbitt, P. M. A. (2002) Individual inconsistency across measures of inhibition: An investigation of the construct validity of inhibition in older adults. *Neuropsychologia, 40*(6), 605 – 619.

Smith, S. M., Gleaves, D. H., Pierce, B. H., Williams, T. L., Gilliland, T. R., & Gerkins, D. R. (2003). Eliciting and comparing false and recovered memories: and experimental approach. *Applied Cognitive Psychology, 17*, 251 – 279.

Starns, J. J., & Hicks, J. L. (2004). Episodic generation can cause semantic forgetting: Retrieval-induced forgetting of false memories. *Memory & Cognition, 32*(4), 602 – 609.

Strange, D., Garry, M. & Sutherland, R. (2003). Drawing out children's false memories. *Applied Cognitive Psychology, 17,*607 – 619.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 18, 643 – 662.

Tipper, S. P., & Milliken, B. (1995). Distinguishing between inhibition-based and episodic retrieval-based accounts of negative priming. . *Converging operations in the study of visual selective attention.* A. F., Krammer, M. G., Coles, & G. D., Logan (Eds). Washington, DC: American Psyhological Association. 337 – 363.

Tipper, S. P., (1985). The negative priming effect: Inhibitory effects of ignored primes. *Quarterly Journal of Experimental Psychology, 37*(A), 571 – 590.

Watson, J. M., Balota, D. A. & Roediger, H. L. (2003). Creating false memories with hybrid lists of semantic and phonological associates: Over-additive false memories produced by converging associative networks. *Journal of Memory and Language, 49*(1), 95 – 118.

Watson, J. M., Bunting, M. F., Poole, B. J. & Conway, A. R. A. (2004). Individual differences in susceptibility to false memory in the Deese-Roediger-McDermott paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*(1), 76 – 85.

Appendix 1

SW Lists	SPW Lists	SW Lists	SPW Lists	SW Lists	SPW Lists	SW Lists	SPW Lists
1 MAD	1 MAD	2 CAR	2 CAR	3 LAKE	3 LAKE	4 THIEF	4 THIEF
angry	angry	truck	truck	river	river	steal	steal
fear	fear	bus	bus	water	water	robber	robber
hate	hate	train	train	stream	stream	outlaw	outlaw
rage	rage	van	van	boat	boat	burglar	burglar
temper	temper	tooth	tooth	swim	swim	money	money
hut	fad	log	par	rust	make	video	grief
fury	fury	drive	drive	summer	summer	cop	cop
top	pad	yes	bar	tone	fake	globe	chief
cross	cross	jeep	jeep	creek	creek	bad	bad
fix	had	web	far	guest	brake	rent	brief
pest	pest	race	race	brook	brook	jail	jail
happy	happy	keys	keys	fish	fish	gun	gun
fight	fight	garage	garage	ocean	ocean	crime	crime
5 BREAD	5 BREAD	6 SLOW	6 SLOW	7 COLD	7 COLD	8 BLACK	8 BLACK
butter	butter	fast	fast	hot	hot	white	white
food	food	quick	quick	snow	snow	dark	dark
eat	eat	stop	stop	warm	warm	cat	cat
sandwich	sandwich	lazy	lazy	winter	winter	burnt	burnt
wheat	wheat	snail	snail	ice	ice	night	night
clone	dread	more	blow	nest	fold	form	hack
jam	jam	careful	careful	wet	wet	funeral	funeral
holy	head	fact	glow	slot	hold	sock	pack
milk	milk	wail	wait	frosty	frosty	colour	colour
mean	tread	edge	flow	time	gold	habit	slack
flour	flour	traffic	traffic	chilly	chilly	blue	blue
jelly	jelly	turtle	turtle	heat	heat	death	death
dough	dough	speed	speed	freeze	freeze	ink	ink
9 SICK	9 SICK	10 KING	10 KING	11 SMELL	11 SMELL	12 FLAG	12 FLAG
doctor	doctor	queen	queen	nose	nose	banner	banner
nurse	nurse	crown	crown	breathe	breathe	American	American
medicine	medicine	prince	prince	sniff	sniff	sign	sign
health	health	princess	princess	stink	stink	stars	stars
hospital	hospital	palace	palace	hear	hear	streamer	streamer
game	pick	types	wing	turn	cell	mug	tag
germ	germ	throne	throne	see	see	stripes	stripes
bond	kick	lump	sing	disk	yell	fox	rag
ill	Ill	chess	chess	pong	pong	pole	pole
left	tick	weird	bring	dunk	bell	hip	nag
pale	pale	rule	rule	whiff	whiff	wave	wave
unwell	unwell	castle	castle	scent	scent	raised	raised
better	better	royal	royal	reek	reek	country	country

13 CHAIR	13 CHAIR	14 TRASH	14 TRASH	15 SWEET	15 SWEET	16 SMOKE	16 SMOKE
table	table	garbage	garbage	sour	sour	cigarette	cigarette
sit	sit	waste	waste	candy	candy	puff	puff
legs	legs	can	can	sugar	sugar	blaze	blaze
seat	seat	litter	litter	bitter	bitter	billows	billows
couch	couch	dirt	dirt	good	good	smog	smog
laser	stair	hall	cash	slide	sleet	wide	joke
desk	desk	bag	bag	taste	taste	ashes	ashes
full	fair	last	rash	title	greet	wink	poke
stool	stool	junk	junk	tooth	tooth	chimney	chimney
task	pair	stump	flash	room	feet	cause	broke
sofa	sofa	rubbish	rubbish	nice	nice	fire	fire
wood	wood	sweep	sweep	honey	honey	tobacco	tobacco
cushion	cushion	scraps	scraps	fizzy	fizzy	flames	flames

17 MAN	17 MAN	18 PEN	18 PEN	19 SLEEP	19 SLEEP	20 TOWN	20 TOWN
woman	woman	pencil	pencil	bed	bed	city	city
husband	husband	write	write	rest	rest	crowded	crowded
uncle	uncle	fountain	fountain	awake	awake	state	state
lady	lady	leak	leak	tired	tired	streets	streets
mouse	mouse	highlighter	highlighter	dream	dream	houses	houses
fit	pan	gap	hen	file	weep	stork	brown
male	male	felt	felt	wake	wake	village	village
owl	fan	fur	ten	load	keep	host	down
father	father	scribble	scribble	snooze	snooze	shops	shops
bet	ban	how	den	hour	steep	bike	gown
strong	strong	crayon	crayon	blanket	blanket	buildings	buildings
friend	friend	marker	marker	doze	doze	malls	malls
beard	beard	paper	paper	nap	nap	place	place

Appendix 2

Stroop Reaction Time Interference and Error Data

	Range	
	Minimum	Maximum
<u>Stroop RT interference</u>		
Overall	0 %	23 %
Inefficient Inhibitors	8 %	23 %
Efficient Inhibitors	0 %	3 %
Unclassified	4 %	7 %
	-1 % *	-7 % *
<u>Errors</u>		
Overall	0 %	18 %
Inefficient Inhibitors	0 %	18 %
Efficient Inhibitors	0 %	12 %
Unclassified	0 % *	11 % *

* 14 participants produced reversed Stroop Interference, longer neutral RT times than incongruent RT times. These participants were included in the unclassified group, as it could not be determined whether they were inefficient or efficient inhibitors.

Appendix 3

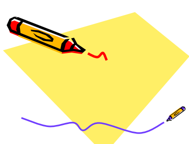
ID ______________________

I would like you to try to press the key that matches the colour of letters or words. I will then show you a list of words, one word at a time. Then I will show you another list of words and ask you to press a key if you saw this word in the first list. If you did see this word in the first, you will then be asked if you remember seeing it or whether you know it was in the first list.

No one will know what your answers are. If you don't want to finish this test you can stop at anytime.

If you would like to do this test, tick the 'yes' box.

Name ___________________________________



Yes ☐ Age ☐

Did you understand what the words meant?

☐	☐	☐	☐	☐
No	A few	Some	Most	All

Appendix 4

You have been asked to help me with an experiment that has two parts.

In the first part of the experiment, a word or group of letters will come onto the screen; you will press the key that is the same as the colour of the word or the letters. For example, if the word "blue" comes onto the screen, you would press the "red" key. If the letters "cbon" come onto the screen, you would press the "blue" key. You will need to press the key as fast as you can without making too many mistakes. If you make too many mistakes, slow down.

Appendix 5

The second part of the experiment involves lists of word. A number of words will come onto the screen, one at a time. After you have seen all the words on the list, you will then do some maths problems, the computer will beep letting you know it is time to stop. Then you will be tested on your memory of the words. A word will come onto the screen and you will decide whether the word was on the list, then you will tick the 'Old" box on the piece of paper, if it was not on the list tick the 'New' box.

Appendix 6

If you 'Remember' seeing the word before, this means you definitely saw the word on the list, so tick the 'Remember' box. Another way to think about this is if you met me next week, if you 'Remember' meeting me, you would remember meeting me and that I talked to you about this experiment.

If you 'Know' you saw the word before, then this means you are certain that you saw it, but not as much as if you 'Remember' seeing it, so tick the 'Know' box. Another way to think about this is you met me next week, you might think that you 'Know' me, but cannot remember where you met me, you might think, was it at a shopping mall, or the library or at school?

Appendix 7

Id ____________ Study List ____

List 1

1	Old	☐	New	☐	Remember	☐	Know	☐
2	Old	☐	New	☐	Remember	☐	Know	☐
3	Old	☐	New	☐	Remember	☐	Know	☐
4	Old	☐	New	☐	Remember	☐	Know	☐
5	Old	☐	New	☐	Remember	☐	Know	☐
6	Old	☐	New	☐	Remember	☐	Know	☐
7	Old	☐	New	☐	Remember	☐	Know	☐
8	Old	☐	New	☐	Remember	☐	Know	☐
9	Old	☐	New	☐	Remember	☐	Know	☐
10	Old	☐	New	☐	Remember	☐	Know	☐